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## **SECTION 401 – PLANT MIX PAVEMENTS – GENERAL**

### **401.1 – GENERAL**

Plant mix pavements comprise a large percentage of the State's highway system. They provide a stable yet somewhat flexible pavement, particularly suited to our traffic needs and our climate.

To continue our good reputation for relatively smooth riding and long lasting pavement, vigilant inspection by the project and Bureau of Materials and Research personnel is required throughout each phase of its production, lay-down, and rolling.

The plant inspector's function (for non QC/QA mixes) is to ensure the quality of the bituminous mix. Specifically, the plant inspector is to make tests to check the quality of ingredients, their proportions, and their temperature to maintain compliance with the job-mix formula, which is provided by the Bureau of Materials and Research prior to beginning paving. The plant inspector also must check hauling units prior to loading.

The paving inspector's duties are numerous and varied. Prior to commencing paving operations the existing surface to be paved and the paving equipment must be checked for compliance with specifications. This includes the setup of the equipment with respect to the widths of the roadway, the type and number of rollers, the proper rolling procedures, the use of grade and/or slope automation, and the staggering and placement of longitudinal and transverse joints. The construction of joints and the appearance of the mat require continuous observation by the inspector. Checking the layout ahead of the paving is also the responsibility of the project personnel. The personnel must be sure the contractor is aware of the specifics of the plan as the pavers move through the job. Examples of this would be guardrail and curbing areas, widened shoulders, crown placement for grade changes, and differing depths. Surface smoothness and good riding qualities of a pavement can be attained only by hard work and strict attention to small details on the part of the project personnel. After all these particulars have been established the final variable to consider is the weather. It is the project personnel's determination as to when to begin and when to end given the ever changing conditions encountered in a day's run of paving. A smooth riding pavement costs no more than an unsightly, poor surface, but it does require constant, careful inspection of all details of construction to obtain the desired results.

The development of the Quality Control/Quality Assurance (QC/QA) specification requires the Contractor to develop and follow a plan to provide a pavement with the characteristics described above. Quality Control is defined as "The sum total of the activities performed by the contractor to make sure that a product meets contract specification requirements". Quality Assurance is defined as "All those planned and systematic actions necessary to provide adequate confidence that a product will satisfy given requirements for quality". The Contract Administrator and assistants are responsible for assuring the Contractor follows the approved plan, and also for the random sampling and testing that form the basis for any pay incentive or disincentive. The following descriptions of the materials and equipment used for paving must be

understood by all people involved in the paving operations, both the Contractors' and State personnel. Contract Administrators and Assistants cannot responsibly monitor any paving operations without a thorough understanding of the materials, procedures and equipment used.

## **401.2 – MATERIALS**

### **A. Aggregates**

The aggregate in the bituminous pavement gives the pavement its mechanical stability. It supports the traffic load, and transmits the load to the subbase at a reduced unit pressure. The various types of granular aggregates readily available and suitable for bituminous mixtures are sand, gravel, and crushed stone. Typically aggregates are produced by either a quarry or pit operation. In a quarry operation the material is blasted from a face then crushed to meet gradation. In a pit operation the material is excavated then screened and crushed to meet gradation. These different aggregate sources can create two very different pavements. This is why it is good to know the origin of your aggregate.

Aggregates are combined to give a gradation having certain characteristics desired or required for a particular use. The gradation is important as it determines, for the most part, the mechanical stability of the bituminous mix.

### **B. Bitumen**

The most common bituminous material in use is asphalt. Asphalt can be found in the natural state in some parts of the world, but most asphalt we use is a product of the petroleum industry. Some of the advantages of asphalt are its cementing characteristics, that it is somewhat flexible, and that it is relatively inexpensive because it is plentiful. Asphalt binders are described by two numbers and thus can be specific to the environment of the pavement (PG 64 –28). The first number represents the hot pavement design criteria in degrees Celsius. The second number represents the cold pavement design criteria in degrees Celsius. A binder for a warmer climate would typically have higher numbers than one designed for a colder climate.

### **C. Job-Mix**

The overall job mix design is the combination of the specified asphalt binder with the correct blend of aggregates to produce a pavement that withstands the traffic loads and maintains durability over time. Given the differing severity of climate from South to North it is easy to understand how much a mix design can change to achieve this goal. In most cases the pavements are being produced from a pre-established commercial plant where the aggregate source does not change over time. In this case, the Materials and Research Bureau should be familiar with the specifics of the aggregate. However, at the start-up of a new season the State's Laboratory personnel should be notified. In the case that the asphalt plant is new or the aggregate source has changed the Contract Administrator or Contractor should provide the Materials and Research Bureau with advance notice of the source of aggregate for the project to allow their personnel time to design the job-mix. On QC/QA projects the contractor shall submit mix designs to the

Material and Research Bureau; provided the design falls within the allowable limits, Materials and Research will approve the mix.

### **401.3 – CONSTRUCTION OPERATIONS**

#### **A. Mixing Plants**

There are two types of asphalt plants, batch and drum, and two types of plant operations: the permanent commercial plant with multiple production operations, and the portable plant erected on or near the project to produce the mixture for that project. The major difference between the two types of plants is that the mixing is done in the drum of the drum plant and in the tower with augers in the batch plant. The drum plant is a continuous mix drum, and the batch plant consists of storage bins for each aggregate size fraction. The asphalt is produced in 3 basic steps: the correct proportioning and mixing of aggregate, the drying and heating of the aggregate to the proper temperature, moisture content and the mixing of aggregate with the asphalt binder.

The State's asphalt plant inspector should visit the commercial plant operation or portable plant as soon as it is set up and ready to operate and examine the equipment for compliance with project Specifications. The plant inspector should become familiar with plant features, noting the mechanical condition of component parts and seeking compliance with current safety standards. The plant operator should correct any mechanical deficiencies or unsafe conditions before beginning mixing operations.

Prior to stockpiling aggregates, the stockpile site must be cleared and leveled. Stockpiles should be separated to prevent intermingling. This may be accomplished with clearly defined stockpiles, or bins, or by using adequate bulkheads. Bulkheads should extend to the full depth of the stockpiles and should be strong enough to withstand pressures that will be exerted under operating conditions. Aggregates must be frequently checked during stockpiling operations for contamination, segregation, and gradation requirements. The stockpiled aggregates shall be of the size and gradation that, when blended together in the proper proportions, will achieve the gradation of the job-mix formula.

The Contractor or Supplier shall furnish an equipped laboratory of the size and type required by the Specifications. It shall be so located that the plant operations are in full view. The testing equipment shall be of the type and in such condition that the laboratory personnel may accurately perform the job control tests required by the Specifications. The laboratory personnel shall have a copy of the job-mix formula, project proposal, Standard Specifications, pertinent addenda to the Specifications, and sufficient forms to record all test reports, materials received, and mixtures produced. All job control tests may be performed at the plant, or part of these tests may be performed by the Materials and Research Bureau as the specific test requires.

Bituminous material storage tanks should be of sufficient capacity to maintain uniform operation while allowing for some delay in shipments. The tanks shall be equipped with sufficient heating coils to heat and maintain the bituminous material at the specified temperature. The coils are usually heated by steam, hot oil, or electricity. During mixing operations the bituminous material should be continuously circulated in the feeder system

between the tanks and the plant. All pumps and feeder lines shall be properly jacketed and heated to maintain the bituminous material at the temperature required. A thermometer shall be located at the outlet end of the feeder line to check the temperature of the bituminous material at the point of use.

The cold aggregate feeder normally used with a portable plant is equipped with four bins, adjustable gates, reciprocating feeders, and an endless belt to carry the proportioned aggregate to the dryer elevator. A commercial plant may be equipped with separate bins, adjustable gates, and a tunnel and conveyor system. In either system, the gates must be adjusted so that the aggregates, in the proper amount and size, are delivered through the plant to the graded aggregate bins in order to maintain uniform production without overflowing the bins.

From the cold aggregate feeder the aggregate is elevated to the dryer, where it is heated and dried to the required temperature and moisture content. The component parts of the dryer are: a revolving cylinder that is usually 20 to 40 ft (6 to 12m) long, a burner that is either gas or oil fired, and a fan which may be considered part of the dust collector system, but its primary function is to provide the draft air for combustion in the cylinder. The cylinder is equipped with longitudinal cups or channels, called lifting flights, which lift the aggregate and drop it in veils through the burner flame and hot gases. The slope of the cylinder, its speed of rotation, diameter, length, and number of flights control the length of time required for the aggregate to pass through the dryer. The aggregate passes from the dryer to the hot elevator through a discharge chute near the burner end of the dryer. The sensing element of a thermometric instrument should be located in this discharge chute to record or indicate the temperature of the aggregate as it passes from the dryer.

The fan exhausts the draft air from the upper end of the dryer into the dust collector system. This draft air contains dust particles, vapor, and gases which enter the dust collector at the upper periphery and go into vertical motion. The heavier dust particles are separated by centrifugal force into the collector shell and fall into the bottom. The heavier dust will be reintroduced into the flow of aggregate or wasted as required by the Specifications. If the exhaust from the dust collector creates a public nuisance, a scrubber must be used to eliminate dust particles from the exhaust air.

The heated aggregates are elevated, usually by a bucket elevator, to a screening unit, which separates the aggregate into the required number of size fractions and deposits the various sizes into the graded aggregate bins. The screening unit, on most plants, is of the flat table vibrating type, usually equipped with four decks. The size of screens on the decks varies with the type of bituminous concrete to be produced. The top deck is covered with a scalping screen which removes all oversize material and discharges this material into a reject chute. The screening unit should be cleaned daily and checked for loose or torn screens.

The bituminous plant shall be equipped with the number of graded aggregate bins required by the Specifications. These bins hold the heated and screened aggregates in the various size fractions required for the type of bituminous mixture to be produced. The

bin partitions must be tight, free from holes, and of sufficient height to prevent intermingling of aggregates. Each bin should be equipped with an overflow pipe that will discharge any excess aggregate from the bin. Bin shortages or excesses should be corrected by adjusting the cold feeder gates. The bottom of each bin is fitted with a discharge gate which may be operated manually or automatically, and the gate's closure should be positive enough to ensure that no leakage into the weigh box will occur. Samples of aggregates from these bins may be secured from "gates" or "windows" in the sides of the bins, or by diverting the flow of aggregates from the bins into sampling containers.

On the batch mix plant, a weigh hopper for the aggregate is located directly under the graded aggregate bins. The weigh hopper is suspended on the weighing mechanism, which is generally equipped with a springless dial scale on which the weight of aggregate from each bin is marked accumulatively so that the last mark will read the total amount of aggregate in each batch. The sequence of weighing from each bin must be strictly observed. The usual and recommended practice is to weigh the coarse fraction first.

The bituminous material is usually weighed into an overflow type bucket suspended on a weighing mechanism with a springless dial scale. A beam-type scale is also acceptable. The Contractor shall arrange for all scales to be tested and sealed by a competent commercial scale company at least on an annual basis prior to the start of the construction season.

In lieu of scales, the Contractor may provide an approved automatic printer system which will print the weight of each material delivered, provided the system is used in conjunction with an approved automatic batching and mixing control system.

The bituminous material is delivered to the pugmill through a calibrated metering pump. The aggregate feeder and the bituminous material pump are geared to a common power source so that proportions of aggregate and bituminous material remain constant, regardless of variations in the power supply.

After proportioning, the aggregate and bituminous material are introduced into the pugmill for mixing. The bituminous concrete plant is equipped with a pugmill mixer which consists of twin shafts equipped with paddles for mixing the ingredients into a homogeneous mass. The main parts of the mixer are the paddle tips, paddle shanks, spray bar, liners, shafts, discharge gate, and heated jacket. Efficient mixing is dependent upon the number and shape of the paddle tips, speed of the mixing shafts, length of mixing time, temperature of the materials, quantity of materials in the mixer, and especially the clearance between the paddle tips and liner plates. The paddle tips and liner plates should be checked for excessive wear. When the clearance exceeds the amount specified in the Standard Specifications, the paddle tips and liner plates shall be replaced.

In the batch mixer the materials are dumped into the center of the mixer and the paddle tips are arranged to give an end-to-center mixing or a run-around (figure eight) mixing pattern. The material is held in the mixer for the required mixing time and then discharged through the discharge gate into the transporting vehicles. The mixer shall be

equipped with an automatic time device to regulate the dry-mixing and wet-mixing periods and a batch counter to accurately record the number of batches produced.

Discussion to this point has described plant mix operation of batch-type mixers. Current Specifications allow the mix supplier to utilize dryer-drum mixers as an alternative method for producing asphalt concrete. Dryer-drum mixers offer simplicity and cost economy in operation, making this method increasingly more attractive to local suppliers.

Dryer-drum mixers differ from batch-type mixers in that there are no screens, hot aggregate bins, or pugmill mixer. Aggregates, stored in cold bins, are supplied by conveyor to the dryer-drum. Belt scales, monitoring the flow of combined aggregates, are interlocked with an asphalt-metering pump to maintain a constant aggregate-to-asphalt ratio. Asphalt is introduced in the drum. Drying and blending of aggregates and mixing of the asphalt and aggregates occur in the dryer-drum. Hot mix is moved from the exit point of the drum via a heated conveyor to a hot surge storage system.

The State's plant inspectors from projects using a dryer-drum facility should check project Specifications for a description of equipment and plant operation. As the dryer-drum plant does not provide means for aggregate gradation control, project personnel should monitor crushing and stockpiling of aggregates. Adequate sampling and testing of aggregates prior to and during production is required to ensure a consistent mix. The plant inspector should also keep an eye on aggregate moisture content as displayed by plant equipment so that the operator may adjust aggregate flow to meet project design mix quantities.

Prior to the beginning of each day's production, the plant inspector should check to see that the various gates, scales, timers, etc. are accurately set before the mixing begins. In addition, the screening unit, bins and overflow vents shall be checked and cleaned.

After mixing begins, and throughout the day, the inspector must supervise or make the required job control tests or submit samples to the Materials and Research Bureau for testing. If possible, an assistant should perform the routine tests, leaving the plant inspector free to observe all the plant operations at frequent intervals. The experienced plant inspector's presence around the plant will contribute much to the production of a uniform mixture.

During the day, the inspector shall make periodic checks of:

1. Cold feeder gates and overflow vents for any overflow of the graded aggregate bins.
2. Temperature of aggregates, bituminous material, and mixture in trucks.
3. The allowable tolerance in gradation for each bin to ensure that it is not exceeded, and that the gradation does not vary widely within the Specifications.
4. Dryer operation.
5. Weighing and mixing operations.
6. The mixture in trucks for uniformity in appearance.

Figure 1 on the next page illustrates the two types of mix plants discussed above.



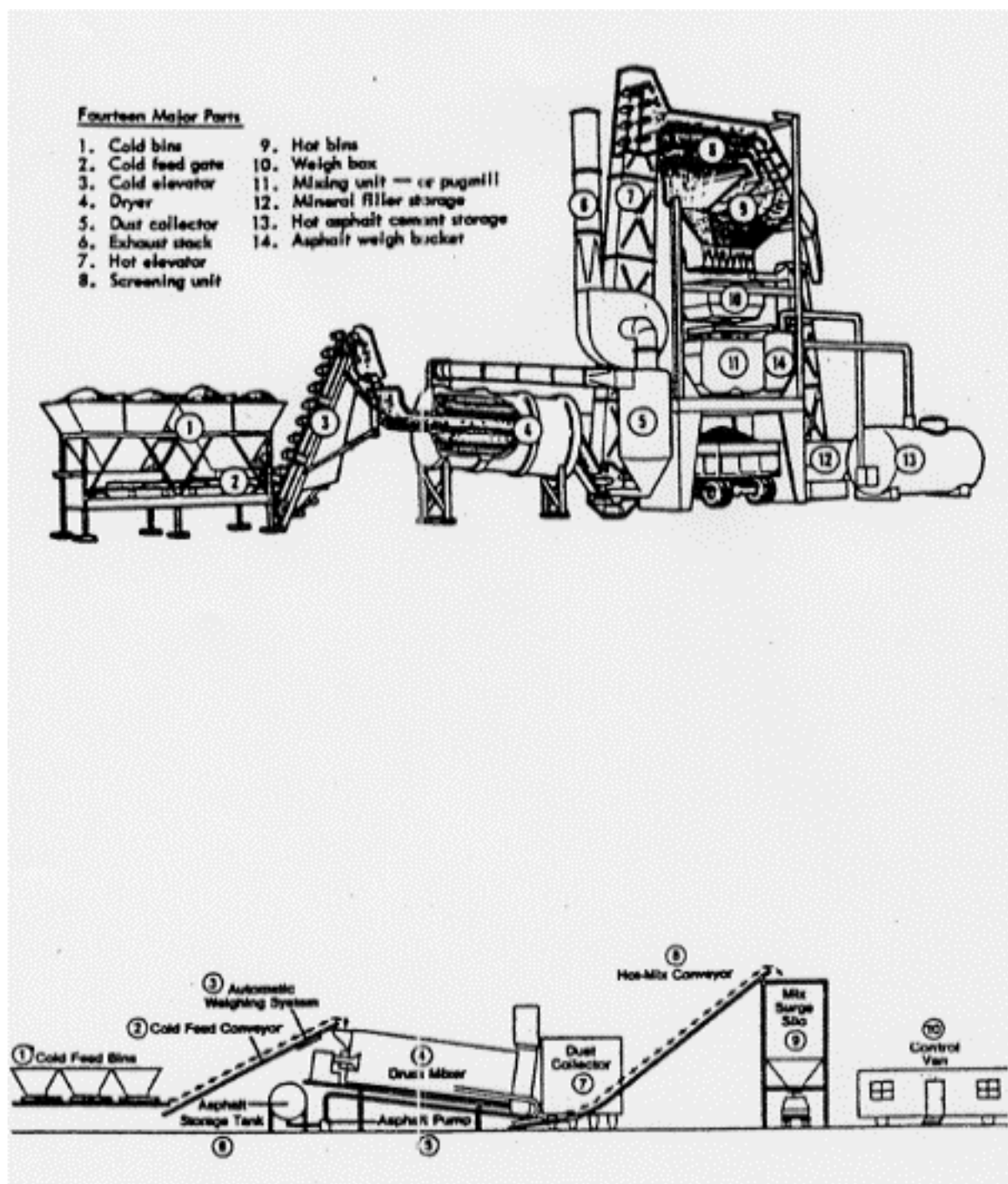


Figure 1: Mix Plants

## **B. Weighing and Hauling**

Truck scales shall be furnished and installed at each plant. The Contractor should arrange for the scales to be tested and sealed by the Bureau of Weights and Measures, Department of Agriculture. Portable scales are to be checked after moving and before use. The State's plant inspector should verify that scales are sealed before any production of bituminous material.

Project personnel will organize delivery tickets daily in numerical order, checking individual tickets and computing Item totals. Adding machine tape showing Item totals and documented with signature and date will be attached to each group of tickets.

Current Specifications allow automatic hot mix batching plants to operate manually for two days when the automatic proportioning or recording system becomes inoperative. The Contractor must have an alternate method of weighing the material to be delivered to the project. When such a breakdown occurs, the Contract Administrator should review the situation with the plant inspector as soon as possible because operation beyond two days requires written permission.

The principal item of inspection in regard to hauling equipment is the condition of the beds or bodies of the trucks that come into contact with the asphalt mix. All contact surfaces should be clean and smooth and free from cracks, holes, or large dents. The inside of each truck bed should be lightly lubricated with a thin soap solution, and the truck should be equipped with a suitable cover. The trucks should be in good operating condition, capable of hauling the mixture without spillage, and capable of dumping the mixture into the paver. The trucks should be checked to be sure that there is no direct frame contact with the paver and that the truck bed or tailgate does not bear down on the paver during dumping operations.

## **C. Placing**

Surface preparation may have more to do with the successful outcome of the paving than the actual paving. The surface to be paved must meet specifications for slope, grade, density, and gradation in order to provide proper support for traffic loads, minimize cracking, and provide the required level of smoothness. Existing pavements should be swept clean and a tack coat applied, if specified. It is also easier to detect abnormalities with the paving mat if surface preparation of the underlying material is accurate. Many of the projects built today require the changing of traffic patterns to fine grade and pave the desired areas. Extra time must be spent to assure the desired surface is achieved.

Leveling course may be used to correct as many irregularities as possible. Many surfaces to be paved are not gravel and thus cannot be graded. Excellent results can be obtained when placing a leveling course with a paver equipped with automation. The paver can sense short sags or bumps and the specified cross-slope can be dialed into place at each desired location. The goal is to correct all of the irregularities with the leveling course so that the actual pavement courses can be placed without making any thickness adjustments. This of course, is seldom entirely accomplished, and any remaining irregularities should be watched for and corrected with each successive layer.

The blade grader may be used to place the leveling course in some re-surfacing contracts. The bituminous mixture is spread on the pavement in a thin layer directly from the dump truck. A roller should work in conjunction with the blade at all times during this operation. The material should be shaped and compacted in thin layers. Additional material should be added as needed, but without dumping an excessive amount of material, which would be wasted. The surface profile and cross section should be checked throughout the operation. Unless specified in the Contract, leveling course should be preformed with a paver.

Excellent results are obtained when placing leveling courses with a bituminous paver equipped with an automatic screed control system. When the stringline is used as a reference, great care is needed in setting the grade line to provide the proper minimum thickness of cover over the controlling high spots in the base, taking into consideration the predetermined cross-slope.

When the automatic screed control system is not used, the amount of profile improvement depends largely on the ability of the screed operator to anticipate the required thickness of the course at any point and make the necessary adjustments far enough in advance so that it is obtained. If the variations in thickness or crown are small or gradual, satisfactory results can be obtained by this method, but if the changes are extensive, complete correction of the irregularities may not be realized. Also, any attempt to visually follow a stringline or other reference set to the desired grade usually fails due to over or under-manipulation of the screed controls. There is a tendency to over mark or micro-measure surface variations. Try to understand the limitations of the machine and work within it's constraints.

Where the required thickness of the leveling course is such that it cannot be placed in a single layer, the surface of each layer should be parallel to the finished grade, starting with a short pass in the area needing the most correction. Each layer should be feathered out at the ends and each successive layer should overlap the ends of the previous layer until the desired surface profile is obtained. Unless each layer is feathered out, a bump will probably be reflected in the finished surface where the leveling course ended.

Between each successive course, the job should be driven to locate areas where further improvement of the profile, crown, or super elevation can be accomplished. By stringing the pavement ahead of the paver, sags are easily detected, and can be marked for correction, either as a separate operation or in conjunction with the placing of the next course. If the area of imperfection is an area that is higher than your finish grade or your next course of pavement, than your only option may be cold planning. Refer to Section 214 for additional information on checking fine grading.

**Checking and Adjusting Bituminous Pavers.** Before placing bituminous mixtures with the paver, the inspector should become familiar with the basic operating principles of the machine. The inspector should check the condition and adjustment of the various working parts that affect the quality of the finished product. However under no circumstance should the inspector touch or change any of the settings on the paver.

There are a number of different bituminous pavers in general use, including Blaw Knox, Barber Greene, Caterpillar, and Cedarrapids. Some characteristics and operating

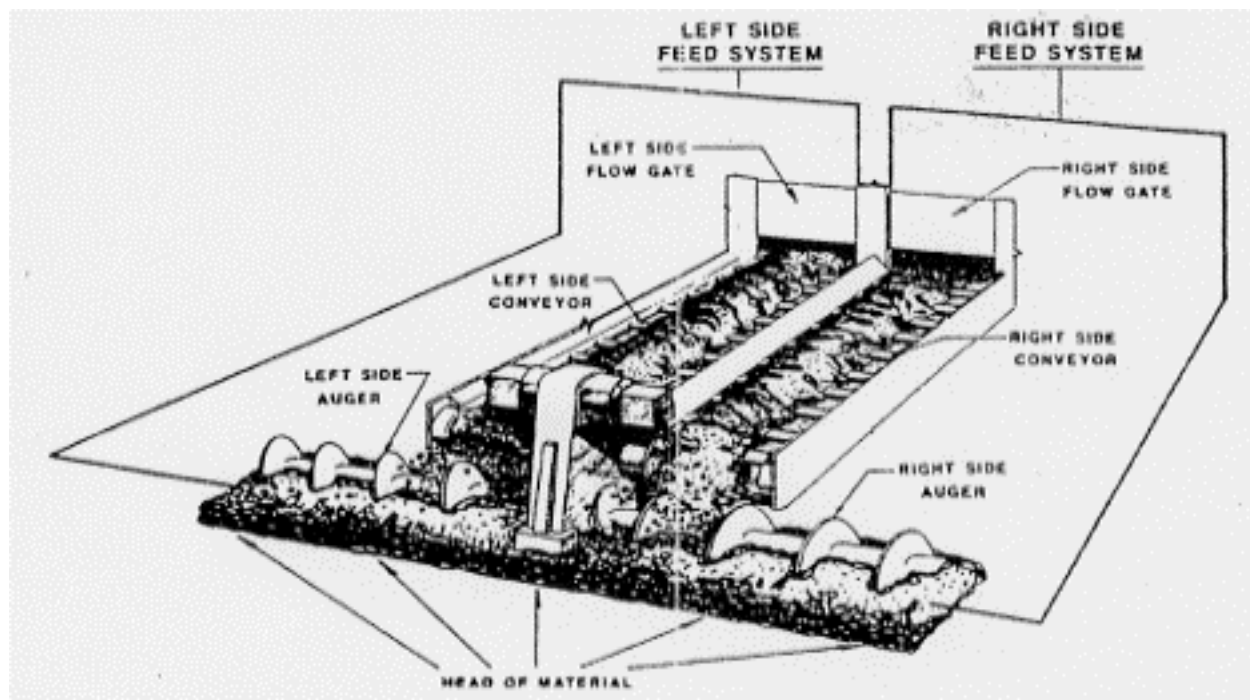
principles are common to the three machines and will be discussed first. An outline of the difference between machines and adjustments will follow.

All machines consist of two basic units: the tractor unit and the screed unit. The tractor unit includes the power plant and controls, the receiving hopper, and the distribution screws, or augers. The screed unit strikes off the mixture and provides initial compaction. It includes the screed and its heaters, thickness controls, and crown controls.

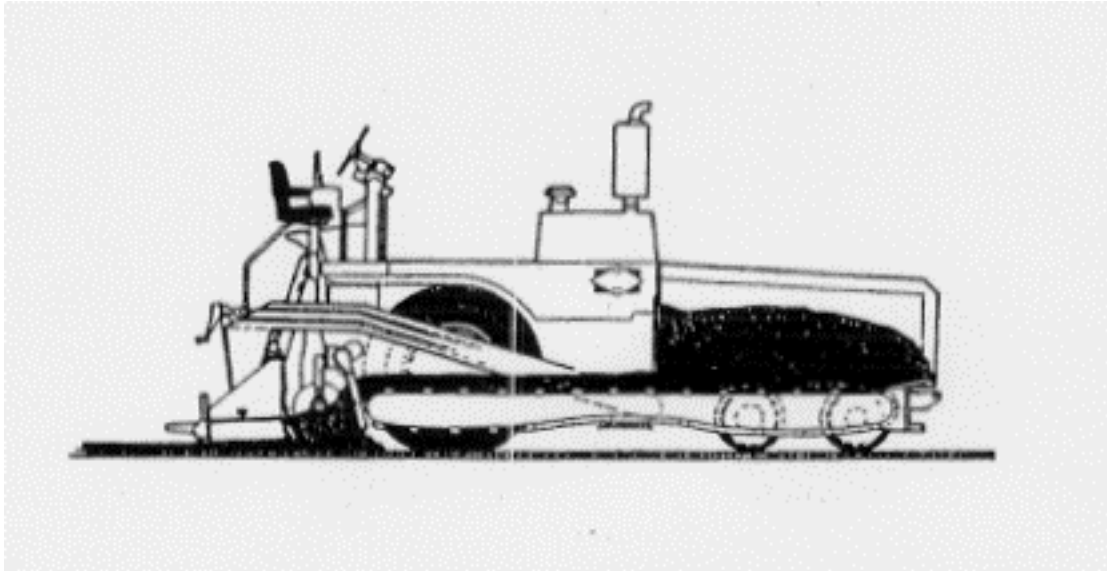
The paving machine may be equipped with pneumatic tires. If so, the paving inspector should check for tire condition and uniform tire pressure. Pavers can also move via crawler tracks. In this case, the inspector should see that tracks are snug, but not tight. Drive sprockets should not show excessive wear. Low tire pressure or loose crawlers can cause unwanted movement of the paver. That movement will transmit to the screed, showing up as a rippling in the pavement surface.

The engine of the paver supplies locomotive power and also powers vibrators on the screed. A governor, if in proper operating condition, ensures a constant engine supply. There can be no lag in power when the engine is loaded, as the lag will cause a failure of screed vibrators, resulting in uneven pavement densities and pavement rippling. Power lags can also interfere with operation of electronic screed controls.

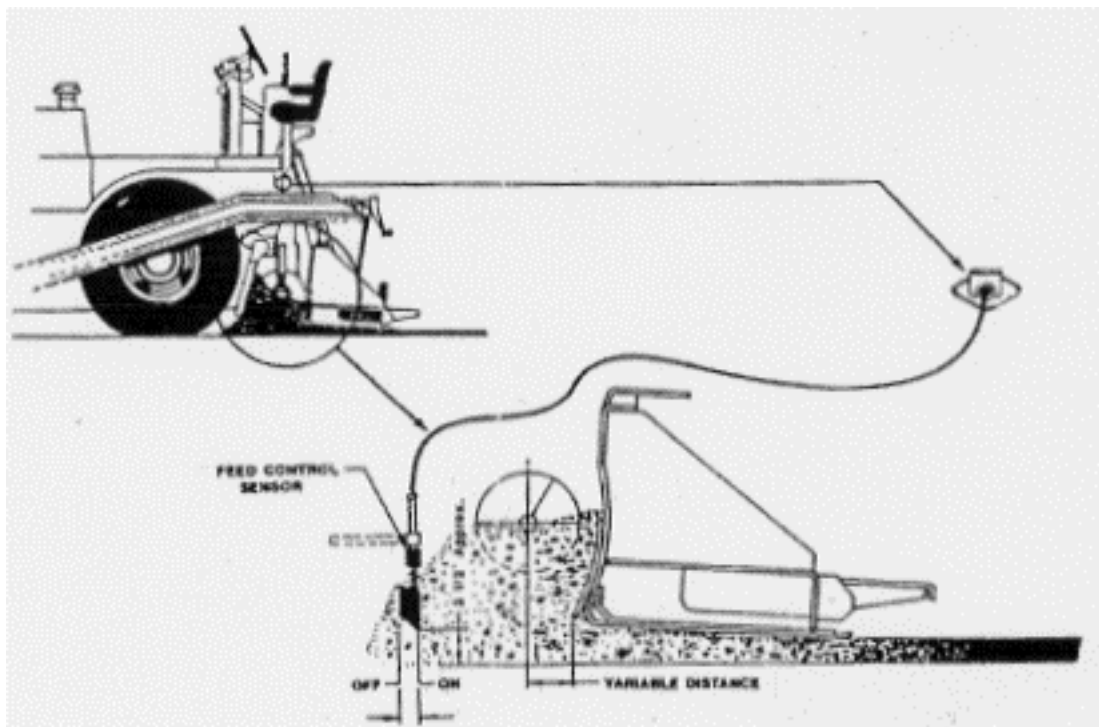
Hot bituminous mix moves by slat feeders (bed chains) from the receiving hopper to the distributing augers at the screed. Figure 2 illustrates a typical material feed system. Adjustment flow gates regulate the amount of mix reaching the augers. Ideally, the slat feeders should run for 80 to 90 percent of the time paving is in progress. They should supply enough mix to keep the length of the augers half covered. The level, or head, of material in front of the screed should remain constant. A fluctuating level of material at the screed results in a rough mat, segregation of material, and imperfection in the riding surface. Older pavers have a hand crank for adjusting the height of the flow gate. Newer pavers are equipped with automatic sensing devices at the end of the augers that control the amount of mix supplied to the screed. See Figures 3 and 4 for examples of these two types of flow control. The paving inspector should see that the adjustment of the sensing device is coordinated with the height of the flow gates so that the slat feeders operate most of the time. Unequal demands for mix at opposite ends of the distributing augers will cause the slat feeders to run unevenly; the flow gate height may also have to be adjusted accordingly. Generally, the wider the pavement, the lower the flowgate opening should be.



**Figure 2: Bituminous Material Feeder System**



**Figure 3: Flow Gate Adjustment, Crank Method**



**Figure 4: Flow Gate Adjustment, Automatic Method**

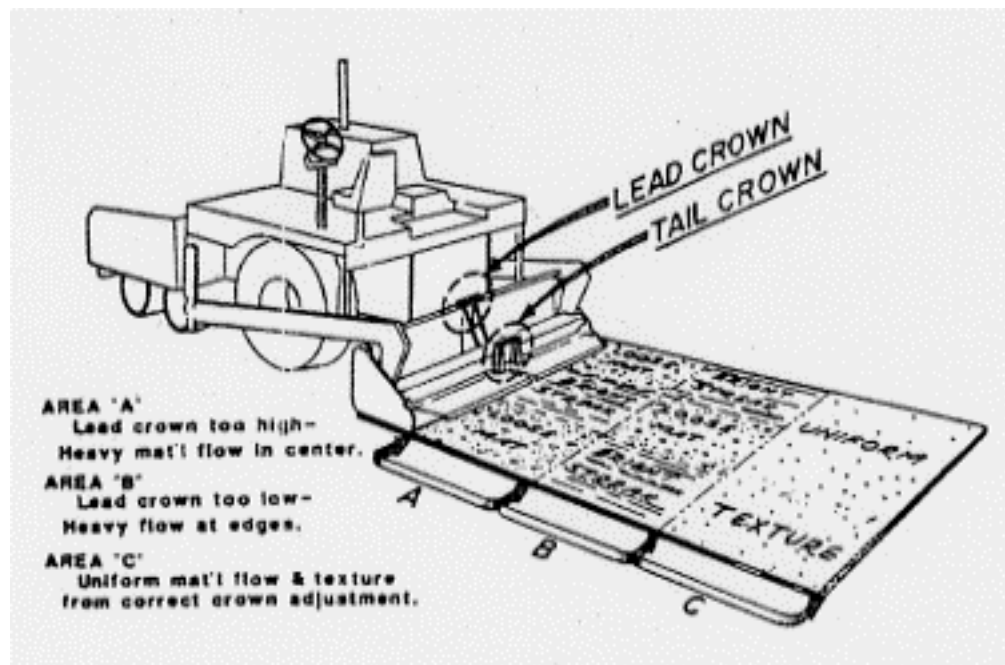
The screed units, for all paving machines, are towed by long arms attached to pivot points located forward on the tractor unit. This permits the screed to “float”, compensating for irregularities in the base. The action and height of the screed provide the mat surface. Adjustments to the screed alignment change the mat thickness.

Generally speaking, the method for changing mat thickness is the same for all pavers, though the distance in which the change takes place may differ among the various manufacturers. Typically it will take 20-30 ft. or approximately the length of the paving machine. The screed is designed to seek a level parallel to the direction of pull. Adjustments for mat thickness are made by tilting the screed up or down around a pivot point located just above the screed. The screed rises or drops until it levels out on a line parallel to the forward motion of the tractor unit. As the screed is supported by the new mat, an immediate change in mat thickness is impossible. The screed will not seek its new level until the machine moves forward. The effect will not be realized until the paver moves approximately 30 ft (10m). The screed unit should move several paver lengths before making further adjustments.

Any paver used, by specification, must have provisions for automatic control of longitudinal grade and transverse slope. Though the automatic control systems used on the various makes of pavers differ from one another, they use the same principle of automation. A sensor riding on a reference (ski, stringline, straightedge, or pavement) actuates valves which control hydraulic pistons attached near the pivot points to the screed arms. Movement of the pistons causes the screed to tip and seek a new level, up or down. Transverse slope is controlled by a pendulum which acts through switches to actuate the appropriate piston. The sensitivity of the controls is very critical to mat smoothness. The sensors should be properly nulled as recommended by the manufacturer.

The screeds of all pavers may be adjusted for crown. Usually it is desirable to provide a small amount of crown in the screed to avoid the appearance of the mat being low in the center of the lanes. The usual crown allowed on rural pavement is 1/8" (3mm). Urban cross sections often require special treatment. The amount of crown at the front edge of the screed, or lead crown, is generally increased from that required at the back of the screed, or tail crown. This differential may be varied with different paving materials and may sometimes be helpful in improving and eliminating non-uniformity of the surface texture across the paved width.

Prior to paving, the paving inspector should check the crown of the screed by pulling a string across the bottom of the screed. Adjustments are made by turning the appropriate nut at the center of the screed. The adjusting nuts should be locked in position with a double nut or locking coupling when the proper screed configuration is made. The inspector should check the rolled mat behind the paver as paving progresses to verify correct crown adjustment. Further changes should be gradual. Figure 5 illustrates how to adjust the screed to control the crown.

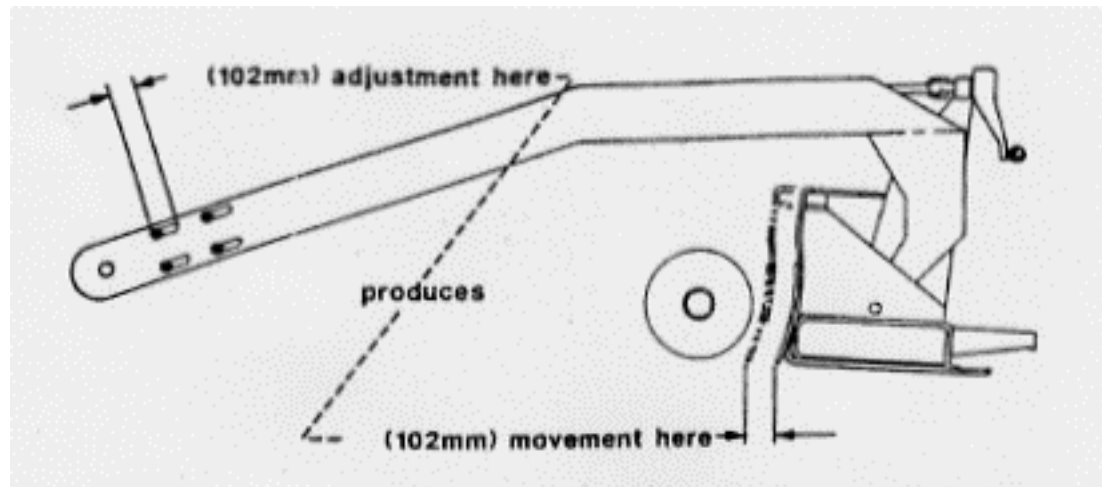


**Figure 5: Screed Crown Adjustment**

While stringing the screed bottom, the paving inspector should note the condition of the screed plates. The plates generally wear out first about 4"-6" (100 to 150 mm) from the trailing edge. The first indication of wear will be either a concave undulation or actual ripples in the plate surface or a streak in the center of the mat. Extensions to the screed should also be checked to see that they are bolted properly and that they form a true extension of the plane of the screed plate.

Screed position is the distance between the distributing augers and the screed, and is adjustable for different bituminous mixes and varying mat thicknesses. Screed position is changed by varying the lengths of the screed side arms. Generally, the screed is set at the midpoint of its adjustment range. Because screed position greatly affects the head of bituminous mix in front of the screed, the adjustment should be the last one made prior to paving. Moving the screed closer to the augers may be effective when paving over soft bases to prevent "dead" material from falling in front of the screed shield and dragging holes in the mat. Moving the screed away from the augers may be advisable when paving extremely deep lifts or paving with large aggregates. Figure 6 illustrates how to adjust the screed position relative to the augers.





**Figure 6: Screed Position Adjustment**

Quarterline cracking or raveling of the mat is caused by worn interior augers, paddles, or baffles, which tend to starve the screed near the center of the paver. Such equipment should be regularly inspected, and if excessively worn, should be replaced or rebuilt to the original dimensions.

Operational features peculiar to each of the machines and adjustments which the inspector should check before starting paving and periodically throughout the process are given in the following paragraphs.

On newer machines, the screed plate itself is vibrated to obtain initial compaction. The amount of vibration is determined by the frequency and magnitude of the vibrator shaft. The frequency is controlled by the vibrator flow control valve, which is located under the screed step. The amplitude of the vibration is controlled by weights on the vibrator shaft. Two pairs of oblong weights may be placed in any of four positions to control the amount of vibration of the screed.

It is important that the tires on the paver should be maintained at a uniform pressure for all tires. The manufacturer recommends a minimum pressure of 36 PSI (248 kPa) when hydro-inflated and 90 PSI (620 kPa) when only air is used. Pressures should only be checked by the contractor's men with the state personnel observing.

14. Paver Operation. Control of the vertical position of the paver's screed with respect to the grade of the existing surface is essential to placing a smooth riding bituminous mat. During the paving operation, several factors influence the vertical position of the screed. They are:

- a. Screed angle of attack - the angle of the screed bottom in relation to the grade of the existing ground.
- b. Head of material - the amount of mix provided to the screed by the augers.
- c. Paving speed - the forward motion of the paver.
- d. Pre-compaction of the bituminous mix.
- e. Consistency of the bituminous mix.

Variation in any of these factors will cause a change in mat thickness, mat density, or mat texture. The secret to good quality paving is to find a good balance of these factors and to maintain consistency once that balance is achieved. Of these factors, the first three are primary to the paving operation and deserve appropriate attention.

If all other factors remain constant, a change in the screed angle of attack changes the thickness of the new mat. Increasing the screed angle of attack allows more material to pass under the screed, forcing the screed to rise. Decreasing the screed angle of attack allows less material under the screed and causes the screed to drop, resulting in a thinner mat. The screed angle of attack may be changed in either of two ways. Screws allow for manual adjustment of the screed at the pivot point above the screed. Control of the height of the tow points where the screed arms join the tractor unit, by either manual or automatic means, also changes the screed angle of attack.

The volume of material in front of the screed is known as the head of material and exerts an amount of pressure or resistance to the forward motion of the screed. Assuming all paving factors are constant, changing the head of material will also change mat thickness. Too much material causes the screed to rise; too little material starves the screed and allows the screed to settle, producing ripples. The paving inspector should look for a constant supply of mix to the screed. Production and delivery problems such as mix temperature, blend, and moisture content can affect the head of material. Adjustments to the paving machine at the flow gates, automatic feed, augers, and screed arms as previously discussed will remedy any problems.

Paving speed will also influence the head of material, which in turn affects the screed angle of attack. An increase in paving speed will decrease mat thickness, and a decrease in paving speed will increase mat thickness. The speed of the paving operation is determined by the rate of delivery of bituminous material to the paver.

The ideal paving operation has the paver running continuously, at a speed producing a good dense mat with uniform appearance. The speed of the paver must be in balance with plant production, utilizing material as it arrives at the paver. The paver should not have to stop and start with each load of mix. Trucks should not stack up. Fewer interruptions and changes in paving speed result in a smoother finished surface.

Below is a table that can be used as a guide for computing the necessary forward speed of the paver for continuous operation:

<b>Relation of Paver Speed to Plant Production</b>			
<b>Mat Thickness</b>	25 mm(1")	38 mm(1.5")	50 mm(2")
<b>Plant Volume</b>	<b>Paving Speed in m/min.(ft./min)</b>		
90 metric(100) tons/hr	7.2(24)	5.4(18)	3.6(12)
140(150) metric tons/hr	11.3(36)	8.5(27)	5.6(18)
180(200)metric tons/hr	14.5(48)	10.9(36)	7.3(24)
230(260) metric tons/hr	18.5(60)	13.8(45)	9.3(30)

The above rates are based on an assumption of 58.6 kg/m<sup>2</sup> of material per 1" (25 mm) of pavement thickness and a 12 ft (3.6m) lane width.

There is a tendency for the paver operator to run the machine at a high rate for a few minutes and use up the material on hand, then stop and wait for more material to arrive. This type of operation should not be permitted, since during the wait the working parts of the machine and the remaining mix cools off and the screed may settle into the mat. When the paver starts up again, a bump in the pavement as well as a scarred and open texture on the surface may result. Generally, paver speed should be limited to the speed that will allow an empty truck to get out of the paver and a full one to get into the paver with mix being dropped into the hopper.

Pavers are equipped with screed heaters which are used to heat the screed until such time as its heat can be maintained by the hot mix.

When there is any appreciable delay in machine operation, it is good practice to run all of the material out of the paver and stop the paver as the screed begins to run out of material. Before starting the paver again, sufficient hot material should be augered back to the screed, and the paver should be allowed to stand until colder material in front of the screed has warmed up.

The dumping vehicle should be held against the rollers on the paver by the use of the truck's brakes to prevent bumping of the machine and spillage of material in front of the paver. Any spillage of material in front of the paver should be cleaned up to prevent the formation of a bump. Trucks should never be allowed to pull the paver.

15. Inspector of Delivered Mixtures. All loads of hot mixtures should be covered to minimize heat loss during transportation. When arriving at the paver, the covers should be rolled back, and the inspector should observe the appearance of the load before it is dumped into the paver. A properly designed and controlled mix will arrive in a slightly mounded condition, of uniform color and texture, and without separation of aggregate or bitumen. The less stable mixes may flatten out in the truck box, but any loads arriving in a fluid condition or with free bitumen on the surface indicates excessive bitumen content and should be rejected. Likewise, visual inspection will detect loads with more than

occasional uncoated particles or evidence of segregation, loads that are too hot, evidenced by smoking; and loads that have lost too much heat in transit, evidenced by a hardened crust on the surface or on the edges. Loads showing these characteristics should also be rejected.

The inspector must receive a weight ticket from the truck driver for each load of bituminous mixture delivered. The inspector must inspect the ticket and, if the load appears satisfactory on the basis of visual inspection, sign the ticket to verify that the material was delivered and incorporated into the work. Information such as station location and offset are good information to record on the delivered slips.

The inspector will accumulate the tickets and turn them over to the Contract Administrator daily. The practice of a Contractor's employee collecting the tickets from the truck drivers and turning them over to the inspector at intervals is not to be permitted.

The temperature of the delivered mixture should be checked periodically, and if the temperature is lower or higher than desirable, this condition should be indicated in a message and sent to the plant inspector for adjustment of the mix delivery temperature. The optimum temperature will vary with the materials used and the prevailing atmospheric conditions, but generally the temperature should be as low as possible for proper workability, placement and compaction on the road, and still allow for proper mixing and coating of the particles at the plant. This will also help quicken the time that traffic can return onto the newly paved roadway. The temperature checks should be recorded on the delivery slips.

The problem of temperature control of the mixed materials may become acute due to bunching of the trucks on the street prior to spreading, intermittent operation of the mixing plant, retention of mixed materials in the plant loading hopper or storage silo, cooling of the mixture in transit, and atmospheric temperatures.

16. Placing Mixtures. On aggregate bases carrying traffic, chuck holes and raveled areas frequently develop in the base between the time it is shaped and the time the mat is placed. If the damage is extensive, it may be necessary to reshape the base, but usually the base can be satisfactorily restored by filling the depressions with the paving mixture. If the depressions are approximately 1" (25 mm) or more in depth, they should be filled and compacted ahead of the paving operation. The maintenance of the base is the Contractor's responsibility, and any material used to fill chuck holes and raveled areas in lieu of re-grading is not to be included in the pay quantity.

It is difficult to preset manhole covers and other castings encountered in municipal work to the proper elevations. Accordingly, castings are frequently referenced, paved over with the binder course, and then dug out and adjusted just prior to placing the wearing course in order to eliminate any unsightly appearance of patching around the fixture in the completed pavement. Typically such structures are set flush with binder so that the finish grade is approximately 1" below finish grade of the wearing course.

Periodically, the inspector shall compute the yield by totaling the quantity actually placed and comparing that total to a total computed for the same area. A regular check of the yield will reduce the possibility of overruns or underruns in quantities and provides an indication of the actual average depth of the mat without over-marking of surface of the

pavement. The yield check can be made on the back of the delivery slips and will serve as documentation. This check should be made both periodically during operations and at the end of each day's run. If yield computations show a drastic difference from the paving slip totals the contractor should be notified and the problem resolved.

#### **D. Compaction**

The object of rolling a bituminous pavement is not only to produce a smooth riding pavement, but also to produce a high degree of density and a tightly knit surface, qualities which are essential to the durability of the mat. Correct compaction equipment is essential and should comply with that specified in the Standard Specifications.

The timing of the initial or breakdown rolling, the intermediate rolling, and the final rolling and the temperature of the mat at which these operations can be performed vary with the type and shape of the aggregate, gradation of the aggregate, inherent stability of the mix, type and condition of the base or foundation, atmospheric conditions, etc. Infrared handheld thermometers aid the roller operators in determining when to begin rolling. Procedures on each project must be adjusted through experimentation to produce the best results. Particular attention should be given to proper tags and frequency settings as specified in the Standard Specifications.

**Initial Rolling:** The initial or breakdown rolling should be accomplished as soon as possible after the material has been spread. The initial rolling shall be done with a static or vibratory steel-drum roller. A partial listing of vibratory rollers appears later in this section.

The drive wheel of the static roller should be forward in the direction of paving so that the mix is drawn under the roller and not pushed ahead in a wave. The roller should be operated very slowly to minimize displacement and promote particle orientation for increased density. Care should be taken with vibratory rollers to correlate roller speed and frequency for a smooth finished surface.

Rolling should begin on the outside or low edge of the lane and progress toward the high side. Static rollers should overlap the previous pass by one-half the width of the roll and vibratory rollers should overlap the previous pass by at least 3" (75 mm). The roller should roll up as close to the paver as possible on each pass, then return in the same path so as to get full initial coverage. Vibratory rollers must be turned off the vibratory when reversing directions. Stopping and reversing the roller at the same transverse location in adjacent passes should be avoided. All turns are to be made on pavement which has been rolled at least once.

The same rolling procedure is followed on successive lanes, except that the longitudinal joint is rolled first, overlapping the fresh mix only 6"-8" (150 to 200 mm) of the roller width. This may require the use of an additional flagger to control traffic, as the roller needs the extra width to perform this pass.

**Intermediate Rolling:** Intermediate rolling is done with a rubber-tired roller. The rubber-tired roller, in most cases, is the key to achieving the required compaction. The

individual tires, in conjunction with the rubber, tend to work the pavement in a “kneading” manner that successfully closes much of the air voids left after the initial, break down rolling. Particular attention should be given to the proper tire pressure as specified in the Standard Specifications. The rollers should be operated continuously between the breakdown and finish rollers, so as to get as much coverage as possible. The rolling pattern should be the same as described for initial rolling, but higher speeds are normally permissible and desirable to obtain more coverage.

One problem with the operation of rubber-tired rollers is that the hot mixture sometimes sticks to the tires and is picked up. This is often used as an excuse for not rolling the mat when it is hot enough for the rolling to be effective. However, a slight amount of pickup can be tolerated, and one or more of the following measures may be used to minimize or prevent pickup:

The tires must be cleaned of any clinging asphalt.

The tires should be allowed to warm up, using as little water on the wheels as possible. Any water used should be distributed uniformly over all tire surfaces.

A small amount of non-foaming household detergent, or a soluble oil at the rate of one part of oil to 50 parts water, added to the roller water helps to prevent pickup.

**Final Rolling:** Final rolling is performed when the mat has cooled to the degree that few or no roller marks are left by the roller and densification can be accomplished without shoving the mix excessively or causing checking of the surface. This rolling can be accomplished with either a vibratory roller in the static mode or a three-axle tandem roller with the center drum locked. A fully ballasted static roller should weigh at least ten tons. The rolling should continue until all evidence of increased compaction disappears, all checks, creases, ruts, and ridges from previous rolling have been eliminated, and all bumps have been ironed out.

For vibratory rollers, the recommended spacing between impacts should be 25 mm(1”) or under to assure a smooth surface. The speed of the roller should be adjusted to the manufacturer’s amplitude frequency ratings.

<b>Paver Speed</b>	1.6 km/hr (1MPH)	3.2 km/hr (2MPH)	4.8 km/hr (3MPH)	6.4 km/hr (4MPH)
<b>Frequency (vibrations/min.)</b>	<b>millimeters(inches) traveled between impacts</b>			
1600	16.7(.66)	33.3(1.32)	50.0(1.98)	66.7(2.64)
1800	14.8(.59)	29.6(1.17)	44.4(1.76)	59.3(2.35)
2000	13.3(.53)	26.7(1.06)	40.0(1.59)	53.3(2.12)
2200	12.1(.48)	24.2(.96)	36.4(1.44)	48.5(1.92)
2400	11.1(.44)	22.2(.88)	33.3(1.32)	44.4(1.76)
2600	10.3(.41)	20.5(.81)	30.8(1.22)	41.0(1.62)
2800	9.5(.37)	19.0(.75)	28.6(1.12)	38.1(1.50)
3000	8.9(.35)	17.8(.70)	26.7(1.05)	35.6(1.40)
3200	8.3(.33)	16.7(.66)	25.0(.99)	33.3(1.32)
3400	7.8(.31)	15.7(.62)	23.5(.93)	31.4(1.24)
3600	7.4(.29)	14.8(.59)	22.2(.88)	29.6(1.17)
3800	7.0(.28)	14.0(.56)	21.1(.83)	28.1(1.11)
4000	6.7(.26)	13.3(.53)	20.0(.79)	26.7(1.06)

## E. Joints

Probably more criticism is directed toward joints than any other phase of bituminous pavement construction. The subject of joints includes both longitudinal joints and transverse joints, and also includes the matched joint between an asphalt surface and a portland cement concrete slab.

**Longitudinal Joints:** It is very important that a high degree of density be obtained in the material placed adjacent to a previously placed lane or existing pavement. If insufficient material is placed above the level of the previously placed mat to allow for compaction, the roller will be supported by the previous mat and the material for a short distance from the joint will not be adequately compacted. Ideally, the surface on either side of the joint should match perfectly after rolling of the second pass is completed, but it would be better to have a slight surplus of material and slightly higher elevation on the side of the second pass, thereby ensuring adequate density, than to obtain an absolutely smooth transition from lane to lane with subsequent raveling.

In constructing a longitudinal joint, the paver screed should overlap the previous pass by 1"-2" (25 to 50 mm) and should leave the material higher than the previous pass by the amount of consolidation being obtained under the rollers.

Longitudinal joints should be rolled directly behind the paving operation. Before rolling, the coarse aggregate in the material overlapping the joint should be carefully moved with a broom or a lute, preferably a lute, onto the surface of the unrolled lane. A better method would be to waste the loose material. This leaves behind only the fine portion of the mixture, which will be tightly pressed into the compacted lane at the time the joint is rolled. The brooming should be done directly after the material has been spread by the paving machine. The roller should then be moved onto the previously compacted lane,

letting one wheel project only 3"-6" (75 to 150 mm) onto the new lane. Two or more passes should be made, so as to thoroughly compact this narrow strip down to an even level with the old lane.

When paving in echelon, 2"-3" (50 to 75 mm) of the edge which the second paver is following should be left unrolled, and rolled when the joint between the lanes is rolled.

The use of joint heaters is not a common occurrence unless specified in your Contract. Longitudinal joint heaters, if in good working condition and used properly, will result in a near perfect bond of one lane joint to an adjacent lane. The heated joint must become soft to a depth of 1/8-1/2" (3 to 13 mm) to be truly effective. This should be checked with a putty knife several times during the day's run. It is also very important that the heated joint be rolled as soon as possible, while the material is hot and soft. If, after the heater has passed over the joint, the area is found to be cold and hard, there are several things the inspector must check. First, and the most common fault, is the speed of the paver. The speed may be too fast to give the heater a chance for full effectiveness. If this is the case, the paver speed may be slowed to favor the joint. Secondly, the length of the heater is important and it may be necessary to add an extension unit to conform with the desired speed of operation. It is recommended that the elevation of the heater over the joint be about 1" (25 mm). Direct flame should not contact the pavement.

**Transverse Joints:** When setting up a transverse joint, the full thickness of the mat must be maintained. The mat will decrease to almost zero thickness because of the weight of the screed when material is completely run out under the screed. For this reason, stop the paver when there is a roll of approximately 600 lbs (225 kg) of material ahead of the screed. Use this material to construct the joint using a material such as canvas, burlap, paper, or sand as a base for a temporary ramp to break the bond, protect the joint, provide a smooth transition, and waste the excess. Basically, some method must be used to cut back the end of the cold mat to a vertical edge and full depth of the course. Use a straight edge when cutting the joint so any roll-off from the prior days paving is removed. The use of pavement saws to cut a clean joint on finish courses is encouraged.

The joint may be at right angles to the roadway or on a skew. Be sure that a skewed joint is at a different angle than that of a snowplow. When proceeding from the joint, the paver is placed so the leading edge of the screed is behind the joint, and the screed is supported on the compacted mat by wood or metal strips having a thickness about equal to the amount of consolidation expected due to compaction. The screed should be properly heated, and the auger box filled with hot material to the normal operating level before starting the machine.

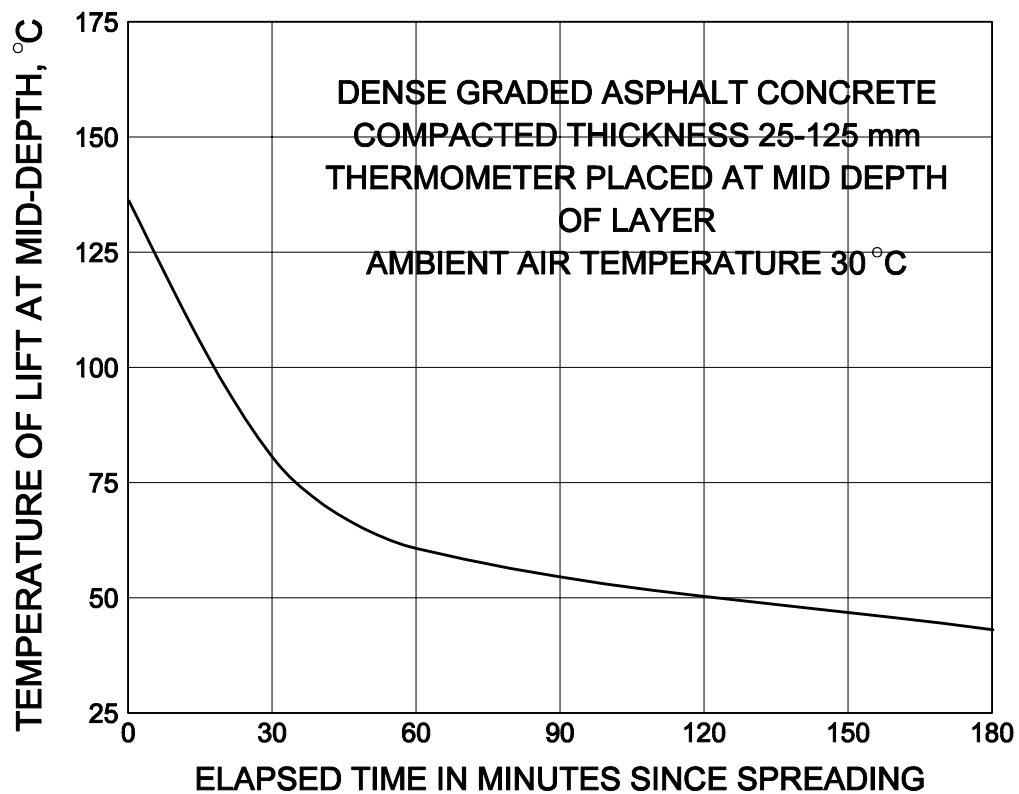
In all courses, transverse joints should be carefully constructed and thoroughly compacted to provide a smooth riding surface. Joints should be straightedged or string lined to assure smoothness and true alignment. If the fresh material is flush with the older pavement it will end up too low after all rolling has been completed. If this is the case, the fresh material should be loosened with rakes to a depth of about 1/2" (15 mm), and the desired amount of material added and raked smooth. The joint should then be rolled in the normal way. If the new material is too high after the pass with the tandem roller, it



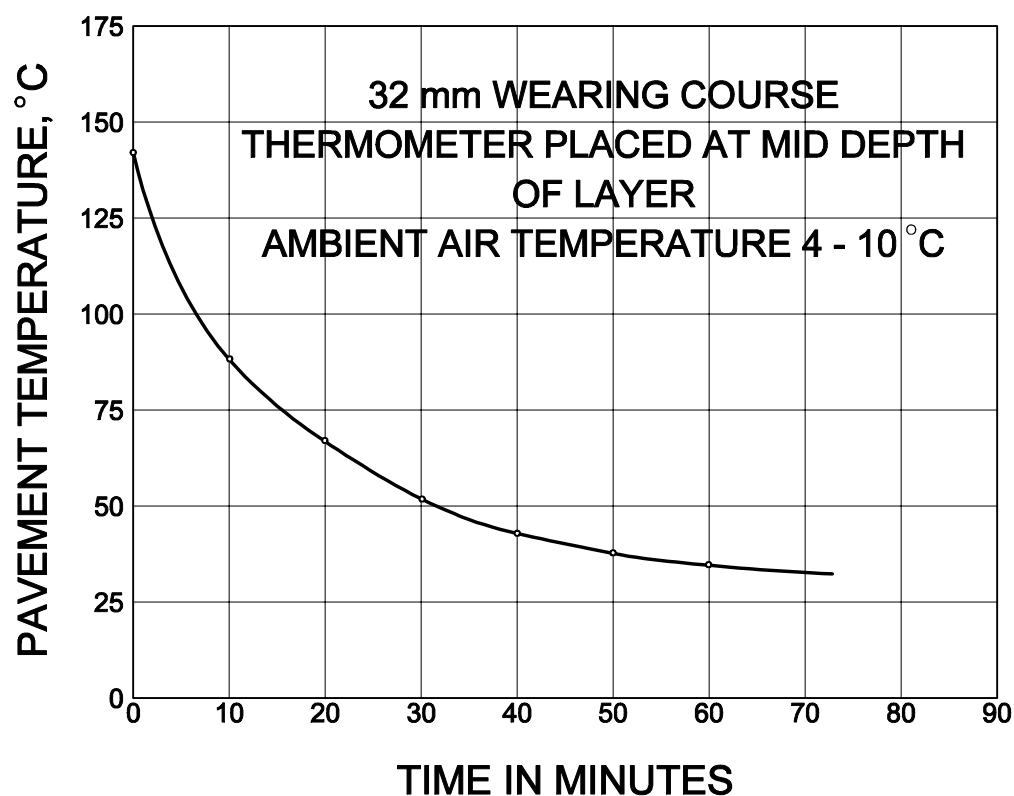
should be loosened with rakes and the excess removed and wasted before continuing with the normal rolling operation. Look for a consistent depth of the mat as you progress away from the joint. It is important to analyze the mat after the paver has pulled off a transverse joint. If all efforts taken still produce an unsatisfactory product the only option is to run out the mix ahead of the screed, sit back on the joint and start again. A large part of the success of a paving job can be determined in how the joints ride. Any corrections to the joint need to be made before the paver and workers disappear down the road. It is far easier to repair a bad joint immediately rather than later.

## Possible Causes of Imperfections in Finished Pavements

Types of Pavement Imperfections That May Be Encountered In Laying Hot Plant Mix Paving Mixtures	Bleeding	Brown, Dead Appearance	Rich or Fat Spots	Poor Surface Texture	Rough Uneven Surface	Honeycomb or Ravelling	Uneven Joints	Roller Marks	Pushing or Waves	Cracking (Many Fine Cracks)	Cracking (Large Long Cracks)	Rocks Broken By Roller	Tearing of Surface During Laying	Surface Slipping on Base
Insufficient or Non-Uniform Tack Coat					X				X					X
Improperly Cured Prime or Tack Coat					X				X					X
Mixture too Coarse				X	X	X	X					X	X	
Excess Fines in Mixture				X				X	X	X				X
Insufficient Asphalt		X				X				X			X	
Excess Asphalt	X		X					X	X					X
Improperly Proportioned Mixture	X		X	X	X	X		X	X	X		X	X	X
Unsatisfactory Batches in Load	X		X	X	X	X			X					
Excess Moisture in Mixture		X							X					X
Mixture too Hot or Burned		X											X	
Mixture too Cold				X	X	X	X	X				X	X	X
Poor Spreader Operation				X	X	X	X		X			X	X	
Spreader in Poor Condition				X	X	X	X		X			X	X	
Inadequate Rolling				X	X	X	X	X						X
Rolling at Wrong Time				X	X	X	X	X	X	X		X		X
Over-Rolling				X						X	X	X		X
Rolling Mixture When too Hot				X	X		X	X	X	X				
Rolling Mixture When too Cold				X	X	X	X	X				X		X
Roller Standing on Hot Pavement					X			X						
Overweight Rollers					X			X	X	X	X	X		X
Roller Vibration					X				X					
Unstable Base Course					X		X		X	X	X		X	X
Excessive Moisture in Subsoil										X	X			X
Excessive Prime Coat or Tack Coat	X		X											X
Poor Handwork Behind Spreader				X	X	X	X							
Excessive Hand Raking				X	X	X	X		X					
Labor Careless or Unskilled				X	X	X	X	X						
Excessive Segregation in Laying			X	X	X	X	X						X	
Faulty Allowance for Compaction							X							
Operating Finishing Machine too Fast				X	X								X	
Mix Laid in too Thick of a Course									X					
Traffic Put On Mix While too Hot									X					






**Figure 7: Cooling Rate of Hot Mix Behind Spreader**



**Figure 8: Rate of Cooling of Hot Mix Behind Spreader**

**Approved Vibratory Roller List<sup>1</sup>**

Manufacturer/ Model	Roll Width (mm) (in)	Operating Frequency	Operating Speed (km/hr) (mi/hr)	Amplitude Setting		
				Surface	Binder	Base
Bomag BW 161 AD	1675 66	2700	4 - 4.8 2.5-3	Low	Low	Low
Bomag BW 220 AD	2030 80	2400	4 2.5			 -3
Bros VM 268H	1725 68	2550	4 2.5	Low	Low	Low
CAT CB 514	1725 68	2500	4 2.5	Low	Low	High
CAT CB 534	1725 68	2500	4 2.5	Low	Med	Med
Dynapac CC42A Series Two	1675 66	2500	4 2.5	Low	Low	High
Ferguson SP 266	1675 66	2500	4 2.5	Low	Low	High

Hamm HO 85B	1675 66	2520	4 2.5	Low	Low	High
Hyster C-727-A	1830 72	2400	4 2.5	Low	Low	Low
Hyster C-766-A	1675 66	3000	4 - 4.8 2.5-3	Low	Low	High
Ingersoll-Rand DD90 (DA 48)	1675 66	2500	4 2.5	Low	Low	Low
Komatsu Dresser VOS 2-66B	1675 66	2400	4 2.5	Low/ Med	Low/ Med	Med
Pettibone C-44	1725 68	2300	4 2.5	Low	Low	Low
Raygo 7204-A	1830 72	2300	4 2.5	Low	Low	Low
Raygo 2-66	1675 66	2300	4 2.5	Low	Low	Low
Tampo RS-166A	1675 66	2200	4 2.5	Low	Med	High

- Notes:
1. This list was updated in 1992 and soft converted to metric in 1996.
  2. Roller operating at 4.8 km/hr (3 mi/hr) must maintain a minimum frequency of 2700 VPM.
  3. Rollers operating at 4 km/hr (2.5 mi/hr) must maintain a minimum frequency of 2200 VPM.
  4. For other frequency/speed combinations, see chart on page 23.
  5. The use of approved vibratory rollers may be used for surface course compaction on projects containing less than 450 metric tons (500 tons) total mix, with the approval of the Contract Administrator.
  6. The right is reserved to remove any roller on the project that does not or can not perform in a manner acceptable to the Contract Administrator.

STATE OF NEW HAMPSHIRE  
DEPARTMENT OF TRANSPORTATION  
CHECKLIST FOR PLANT MIX PAVEMENTS

Project \_\_\_\_\_ Weather \_\_\_\_\_ Temp. \_\_\_\_\_

Station(s) \_\_\_\_\_

Contractor \_\_\_\_\_ Subcontractor \_\_\_\_\_

Paving Maintenance of Traffic and Signing( )	Ten Foot Straight Edge Available on project( )	Thermometer on project( )	Tire Gauge on project( )
----------------------------------------------	------------------------------------------------	---------------------------	--------------------------

**Paver**

Automation Working (if required) ( )	*Screed checked with string ( )
Edge Beater (if required) ( )	*Screed extension with tampers ( )
*Screed in good condition ( )	or vibration ( )

**Trucks - Check on Arrival**

Adequate Covers in use ( )	All dump without spills or bearing on paver hopper ( )
No oil or fuel leaks ( )	

**Rollers**

*Number of rollers required	Ballasted (if required) ( )	Soap or detergent in rubber tired roller ( )
Tandem — Rubber Tired —	*Weight Plates on rollers	( )
3 Axle — Vibratory —	*Rolls in good condition	( )

**\*Steel and rubber tired rollers**

Make and Model	Empty Weight	Ballast	Total	Required Total Wgt.

**Rubber tire roller pressures - Check when hot**

	Front	_____
Equip. No.	Rear	_____
	Front	_____
Equip. No.	Rear	_____
	Front	_____
Equip. No.	Rear	_____

**\*Vibratory Rollers**

Make and Model	Applied Dynamic Force	Required

Contractor Rep. \_\_\_\_\_ Date \_\_\_\_\_

State Rep. \_\_\_\_\_ Date \_\_\_\_\_

\*Check at beginning of paving, when equipment is changed, or as required.  
All other items to be checked prior to or during paving each day. This form is to be completed for each day of paving and retained with the Project Records.

## **SECTION 403 – HOT BITUMINOUS PAVEMENT**

### **403.1 – GENERAL**

Hot bituminous pavement is normally used on new construction projects, as opposed to plant mix surface treatment, which is normally used for resurfacing existing roadways. Plant mix surface treatment is well covered in the Section 401 - Plant Mix Pavements – General.

#### **A. HOT BITUMINOUS PAVEMENT (QC/QA)**

Plant mix pavement placed and produced under the Quality Control/Quality Assurance (QC/QA) specifications are designed to increase the quality of the finished product. This system provides incentive to the Contractor for constructing a good paving job and applies a penalty to those who do substandard work. With an incentive plan in place contractors will strive to produce a better mix.

The difference between the general plant mix specification and QC/QA specification is that many of the day to day inspection responsibilities are transferred from the inspector to the Contractor. The plant inspector and the site inspector are primarily interested in the final results by means of testing the finished product.

#### **B. QUALITY CONTROL (QC)**

The Contractor will present a process control plan for approval according to the requirements of the specification. The approved process control plan tells us how they plan to perform the work. By having the Contractor submit their plan, they can incorporate some flexibility in their operations and how they plan to achieve the required final results. The Contractor will handle the Quality Control of the operation which includes monitoring aggregate production, plant production, and placement.

All project personnel involved with the paving should become familiar with the Contractor's plan and the QC/QA specifications. The plan becomes part of the specifications, and it is the inspector's responsibility to ensure that the Contractor is conforming to the plan. Any time the Contractor deviates from any item in the plan, the inspector should suspend paving operations until the problem is corrected.

The Contractor performs all quality control testing. The results from these tests are solely for controlling operations. The specifications require that the Contractor maintain a complete record of the QC test results, including control charts. This data needs to be checked periodically by the inspector to ensure that the Contractor is testing at the proper frequency and that they are in control of the material.

### **C. QUALITY ASSURANCE (QA)**

QA testing is carried out by Department personnel and is designed to ensure that the final product meets or exceeds specifications. The QA tests are used in calculating a positive or negative pay adjustment for the contractor. Since so much hangs on each test result, tests need to be taken by qualified personnel at locations specified in the specification.

Computation of a pay adjustment works like this: The QC/QA paving item is broken down into lots which are defined as the quantity represented by each job mix formula, i.e., base, binder, wearing course. Next, each lot is broken into 750 ton sublots. Within each subplot, a random location is selected where the test sample is obtained. The test results are listed for each lot and run through calculations outlined in Section 106 and 401 of the Standard Specifications or Special Provisions to arrive at a pay adjustment.

When a Contract Administrator receives a contract with a QC/QA paving item, one of the first steps he needs to take is to determine all of the sample locations for each lot. This should be completed before any paving takes place on the project. First, the lot quantities are determined for each type of mix. Next, for each lot, the project is divided into 750 ton areas based on lane width and pavement depth. This is accomplished by first listing each lane, complete with depth and width; then a subplot length is calculated. Once subplot lengths have been determined for each lane, random locations are chosen within each subplot. Sample locations should not be discussed with the contractor as they should not know in advance where we take samples.

In order to have more, or any control over what goes on, the plan needs to be a 2-way street. Otherwise we are forced to stand back and let them go unrestrained. This plan must address everything that will take place, so there are no misunderstandings at the time paving operations begin. The contractor puts his intentions in the plan, and the State should have its suggestions in the plan as well.

### **D. Pre-paving Meeting**

The next step is to have a pre-paving meeting. This should occur well before paving operations commence and after the Contractor's approved process control plan has been distributed. This meeting is important in that it brings together all parties that will be working with the items to resolve any issues. The Contract Administrator will be responsible for inviting Quality Assurance personnel who will be involved with the paving item. Representatives from Materials and Research Bureau, preferably those involved with the testing, the Contract Administrator's field inspectors, and the Area QC/QA Coordinator should be invited as well. The Contractor should invite the Plan Administrator, process control technicians and material suppliers.

Topics of discussion for the pre-paving meeting should include the following:



- Review the Contractor's process control plan, resolving any misunderstandings.
- Material stockpiles
- Quality Control test results.
- Quality Assurance testing.
- Testing laboratory setup.
- Schedule of events. (Placement sequences)
- Handling and transportation of core samples.
- Labeling test samples.

Once paving begins, the Contract Administrator needs to monitor the Contractor's method of operations. The Contractor shall operate in accordance with the approved plan and the specifications. The inspector should ensure that decisions made by the Contractor regarding quality control are made by authorized personnel listed in the process control plan, and that there is a good line of communication between the plant and the paver.

Even though we are only interested in the "end product", the Contract Administrator still has the authority to reject a load and/or suspend paving operations based on visible defects. Visible defects are, generally, things we do not test for. For example; an improperly matched longitudinal joint, or the mix being over-vibrated and cracking, or visible mat defects caused by screed problems. A load of mix may have uncoated stone or may have too much liquid asphalt, in which case the inspector can reject the load based on visual observation. Paving can be suspended if the process control plan is not being followed. This can include, but not be limited to, a plant malfunction, paver malfunction, unauthorized QC personnel making decisions, or improper QC testing.

The Contract Administrator should ensure that the necessary technicians are available while paving to gather samples from the designated locations. When obtaining samples, consideration should be given that the Contractor is working hard to obtain a smooth ride surface, and we don't want to be responsible for unnecessary footprints in the fresh mat. The inspector should coordinate with the Contractor when obtaining a sample so as not to disrupt the paving operations. Periodically, an inspector should check production at the plant to ensure that the provisions of the process control plan are being met.

After samples are taken, the Contract Administrator should make sure that the results are obtained in a timely manner. As the results are determined, the

Contractor should be given a copy for their records so that they know where they stand for pay adjustments. A pay adjustment can be calculated to go on the partial estimate when a minimum of 3 sets of test results are obtained.

A computer spreadsheet is available to calculate sample locations and pay factors from the Bureau of Construction or from the Area QC/QA Coordinator. This spreadsheet is also available for the Contractors to use so that the same reporting methods and subplot labeling system are uniform throughout the state.

### **403.3 – CONSTRUCTION OPERATIONS**

For assistance in computing periodic yields, the following chart is included in this section. This chart is derived from average densities of compacted hot bituminous pavements. Due to variations in specific gravities of aggregate and differences in specified gradations for base, binder, and top mixes, considerable judgment must be used in interpreting yields computed from this chart. Typically, base mix, due to the large size of aggregate used, cannot be compacted to a high density because of inherent voids. Therefore, yield values may underrun by as much as 10 percent. Binder mix, which consists of slightly smaller size aggregates, exhibits somewhat the same characteristics, and may have yield values underrunning by as much as 6 or 7 percent. Conversely, top mix consists of relatively fine aggregates, and may have yield values overrunning as much as 3 or 4 percent. Bearing these facts in mind, the Contract Administrator can evaluate these individual yield results in light of the combined yield desired in the finished pavement structure.

## Asphaltic Pavement Constants

Depth		25 mm (1")	38 mm (1.5")	50 mm (2")	63 mm (2.5")	75 mm (3")	88 mm (3.5")	100 mm (4")
(Tons/S.Y.) Metric Tons/m <sup>2</sup>		0.0615 (.057)	0.0922 (.085)	0.1229 (.113)	0.1537 (.142)	0.1844 (.170)	0.2152 (.198)	0.2460 (.227)
Width	m <sup>2</sup> /30 m S.Y./100'	Metric Tons/30 m (Tons/100L.F.)						
3.0 m (10ft)	92.90 (111.11)	5.71 (6.30)	8.57 (9.44)	11.42 (12.59)	14.28 (15.74)	17.13 (18.89)	19.99 (22.03)	22.85 (25.19)
3.1m	94.49	5.81	8.71	11.61	14.52	17.42	20.33	23.24
3.2m	97.54	6.00	8.99	11.99	14.99	17.99	20.99	23.99
3.3m (11ft)	100.58 (122.22)	6.19 (6.93)	9.27 (10.39)	12.36 (13.85)	15.46 (17.32)	18.55 (20.78)	21.65 (24.24)	24.74 (27.71)
3.4m	102.19	6.28	9.42	12.56	15.71	18.84	21.99	25.14
3.5m	106.68	6.56	9.84	13.11	16.40	19.67	22.96	26.24
3.6m	109.73	6.75	10.12	13.49	16.87	20.23	23.61	26.99
3.7m (12ft)	111.48 (133.33)	6.86 (7.56)	10.28 (11.33)	13.70 (15.11)	17.14 (18.89)	20.56 (22.67)	23.99 (26.44)	27.42 (30.23)
3.8m	115.82	7.12	10.68	14.23	17.80	21.36	24.93	28.49
3.9m	118.87	7.31	10.96	14.61	18.27	21.92	25.58	29.24
4.0m (13ft)	120.77 (144.44)	7.43 (8.19)	11.14 (12.28)	14.84 (16.37)	18.56 (20.47)	22.27 (24.55)	25.99 (28.64)	29.71 (32.74)
4.3m (14ft)	130.06 (155.56)	8.00 (8.82)	11.99 (13.22)	15.98 (17.62)	19.99 (22.04)	23.98 (26.45)	27.99 (30.85)	32.00 (35.27)
4.9m (16ft)	148.64 (177.78)	9.14 (10.08)	13.71 (15.11)	18.27 (20.14)	22.85 (25.19)	27.41 (30.22)	31.99 (35.25)	36.57 (40.30)
5.5m (18ft)	167.23 (200.00)	10.28 (11.34)	15.42 (17.00)	20.55 (22.66)	25.70 (28.34)	30.84 (34.00)	35.99 (39.66)	41.14 (45.34)
6.1m (20ft)	185.81 (222.22)	11.43 (12.60)	17.13 (18.89)	22.84 (25.18)	28.56 (31.49)	34.26 (37.78)	39.99 (44.07)	45.71 (50.38)
6.7m (22ft)	204.39 (244.44)	12.57 (13.68)	18.81 (20.78)	25.12 (27.70)	31.41 (34.64)	37.69 (41.55)	43.98 (48.47)	50.28 (55.41)
7.0m (23ft)	213.68 (255.56)	13.14 (14.49)	19.70 (21.72)	26.26 (28.95)	32.84 (36.21)	39.40 (43.45)	45.98 (50.68)	52.56 (57.94)
7.3m (24ft)	222.97 (266.67)	13.71 (15.12)	20.56 (22.67)	27.40 (30.21)	34.27 (37.79)	41.12 (45.33)	47.98 (52.88)	54.85 (60.45)

7.6m (25ft)	232.26 (277.78)	14.28 (15.75)	21.41 (23.61)	28.54 (31.47)	35.70 (39.36)	42.83 (47.22)	49.94 (55.08)	57.14 (62.97)
7.9m (26ft)	241.55 (288.89)	14.86 (16.38)	22.27 (24.56)	29.69 (32.73)	37.13 (40.94)	44.54 (49.11)	51.98 (57.29)	59.42 (65.49)
8.5m (28ft)	260.13 (311.11)	16.00 (17.64)	23.98 (26.44)	31.97 (35.25)	39.98 (44.08)	47.97 (52.89)	55.98 (61.69)	63.99 (70.53)
9.1m (30ft)	278.71 (333.33)	17.14 (18.90)	25.70 (28.33)	34.25 (37.77)	42.84 (47.23)	51.39 (56.67)	59.98 (66.10)	68.56 (75.57)
9.8m (32ft)	297.29 (355.56)	18.28 (20.16)	27.41 (30.22)	36.54 (40.28)	45.69 (50.38)	54.82 (60.45)	63.98 (70.51)	73.13 (80.61)
10.4m (34ft)	315.87 (377.78)	19.43 (21.42)	29.12 (32.11)	38.82 (42.80)	48.55 (53.53)	58.25 (64.22)	67.98 (74.91)	77.70 (85.64)
10.7m (35ft)	325.16 (388.89)	20.00 (22.05)	29.98 (33.06)	39.96 (44.06)	49.98 (55.11)	59.96 (66.11)	69.97 (77.12)	79.99 (88.16)
11.0m (36ft)	334.45 (400.00)	20.57 (22.68)	30.84 (34.0)	41.10 (45.32)	51.41 (56.68)	61.67 (68.00)	71.97 (79.32)	82.27 (90.68)
11.3m (37ft)	343.74 (411.11)	21.14 (23.31)	31.69 (34.94)	42.25 (46.58)	52.83 (58.25)	63.39 (69.89)	73.97 (81.52)	84.56 (93.20)
11.6m (38ft)	353.03 (422.33)	21.71 (23.94)	32.55 (35.89)	43.39 (47.84)	54.26 (59.83)	65.10 (71.78)	75.97 (83.73)	86.85 (95.72)
11.9m (39ft)	362.32 (433.33)	22.28 (24.57)	33.41 (36.83)	44.53 (49.10)	55.69 (61.40)	66.81 (73.67)	77.97 (85.93)	89.13 (98.24)
12.2m (40ft)	371.61 (444.44)	22.85 (25.20)	34.26 (37.78)	45.67 (50.36)	57.12 (62.98)	68.53 (75.55)	79.97 (88.13)	91.42 (100.75)

## SECTION 410 – BITUMINOUS SURFACE TREATMENT

### 410.1 – GENERAL

Bituminous surface treatment generally consists of the work involved in “building a roof” on a prepared base or existing pavement. The prepared base or existing pavement is treated either by a prime coat, a tack coat, or a seal coat, depending on the case, and in varying numbers of applications.

The purposes of a prime coat on an aggregate base are primarily to ensure a good bond between the surfacing and the base, to provide a waterproofing of the base course surface, and to stabilize the fine graded gravel surface prior to placing the following courses.

Tack coats are primarily used to increase the bond between an existing surface and a new surface by creating a raw and somewhat sticky surface for the new pavement to adhere to. Seal coats may be used to build up an existing surface for added depth of wearing surface and for sealing surfaces that are cracked and checked.

A blotter material is usually applied in conjunction with the application of bituminous material for the purposes of absorbing excess bitumen which might “bleed” to the surface.

#### **410.2 – MATERIALS**

Material classifications are adequately covered in the Specifications, and shall conform to AASHTO M 140 or M 208.

Generally there have not been any problems with the type and grade requirements of bituminous materials that would require a sample to be tested before being applied at the construction site; however, a sample should be taken from each load with the first to be sent to the Materials and Research Bureau for testing and one out of every five sent thereafter to provide continuing control of the materials. The remaining samples are to be stored for future testing if needed.

The blotter material to be used should be tested for gradation before applying it to bituminous material. Aggregate with too many fines may blot up the bituminous material, resulting in insufficient penetration or bond. Blotter material with a coarse gradation, not in specification would make too rough a surface and damage the treated surface, especially when used on a seal coat.

#### **410.3 – CONSTRUCTION OPERATIONS**

##### **A. Surface Conditions**

In the case of sealing tack coats, the surface to which the bituminous material is to be applied should be dry, whereas the surface to be prime coated should be neither too wet nor too dry. When the surface is too dry, the prime coat will “ball up”. A good practice is to moisten the surface two to three hours prior to priming. This will ensure that a sufficient amount of moisture is present for good penetration.

##### **B. Equipment**

The distributor trucks used to apply the bituminous material are usually well maintained but should be inspected to make sure they are in good operating condition and not leaking fuel or asphalt.

Temperatures should be checked to see that the material is not overheated and that the application temperature falls within the applicable range as stated in the Standard Specifications.

Almost all distributors are equipped with a dial gauge to determine the amount of material in the tank, but it should not be depended upon as the only means of measurement. A measuring stick with increments of volume according to the size of the tank is also available, and the tank should be “stuck” to determine a more accurate quantity to compare with the quantity computed from weights on the delivery slip.

It is especially important to check the spray nozzles to make sure an even coverage and proper spray lap is achieved from the distribution spray bar. Surface aggregates will not adhere to areas missed due to clogged nozzles. The project personnel may also check the volume of the tank or the readings of any gauges to ensure the proper yield of the product.

### **C. Preparation of Surface to be Treated**

The roadway to be treated should be processed, shaped and compacted to a smooth, uniform grade and cross-section before application of the bituminous material. It is essential that the grading of the surface material be uniform over the area to be treated to allow uniform penetration of the material. The quality and smoothness of the finished roadway depend to a great extent on the quality of the work done in preparing the roadway. Careful inspection during this operation will lay groundwork for a smooth riding and uniform appearing finished project.

In many instances, the surfacing course upon which the bituminous surface treatment is to be placed may be segregated, rutted and pot-holed by traffic using the roadway prior to treatment. Such a surface must be completely re-graded to the depth of the ruts or pot-holes. Do not allow the Contractor to merely blade the surfacing course lightly, filling the holes with loose, segregated material. Such procedures are sure to result in a rough uneven pavement, due to differential compaction and penetration.

The surfacing must be thoroughly rolled to obtain a dense, unyielding base for the bituminous surface treatment.

### **D. Application of Bituminous Material**

Before bituminous material is applied, widths should be outlined for the distributor to follow. The Plans usually prescribe rates of application, but the Contract Administrator may find it necessary to change the rate where conditions warrant it.

Excessive overlapping will cause “bleeding” and should be avoided, as bituminous material may build up and cause high spots when blotter material is applied.

### **E. Tar Surface Treatment**

Tar surface treatment is not regularly used as it is normally more expensive than asphalt. Since tar is heavier than water it withstands wet and winter conditions better than cut-back asphalt; therefore, it is often preferred for treatment of new work late in the fall where traffic must be maintained.

As a seal coat, tar may readily be mixed with a limited amount of cover material by the use of the wire brush drag. The leveling action of the drag produces a fine riding surface.

Frequently, when using grades of cut-back asphalt for penetration or seal treatments, the asphalt is carried by traffic onto other pavements, thereby producing a very slippery, hazardous condition. If the new work is subjected to a few hours of rain, emulsified asphalt may be tracked by traffic for a mile or more. A light seal coat of tar (T-5) used with the specified cover material will correct the slippery pavement condition.

Tar should only be used where specifically designated or substituted by the Construction Bureau Administrator.

## **SECTION 411 – PLANT MIX SURFACE TREATMENT**

### **411.1 – GENERAL**

Plant mix surface treatment is normally used for resurfacing existing pavement where less than 1" (25 mm) of new material is desired. Where the depth is to be 1" (25 mm) or more, hot bituminous pavement is normally used. Leveling with a grader using hot bituminous pavement may be required prior to final paving where the edge of the pavement is severely rolled down, rutted, or where sharp sags must be filled.

### **411.2 – MATERIALS**

Materials requirements are thoroughly covered in the Standard Specifications.

### **411.3 – CONSTRUCTION OPERATIONS**

Most of the construction methods used for this Item are well covered in Section 401, Plant Mix Pavement – General; however, the following comments are particular to plant mixed surface treatment.

A rug drag about 12 ft (3.6 m<sup>2</sup>) is often used immediately behind the paver for MC mixes and less often on the emulsion mixes. The drag smoothes and improves the surface texture of the mat. Where there is any question as to whether the rug should be used or not, it is best to use it.

Sand is spread lightly over the mix after rolling with the steel wheel roller prior to the use of the rubber tired roller to make the surface less tacky. Care must be taken that the sand truck delays its application long enough so that its tires do not mark the fresh surface and that when the truck is parked it is either off the work or far enough back so that it is on a cool part of the work.

Most old pavements are uneven, and therefore, depth measurements behind the paver will change rapidly. Due to this variation, yield must be checked by computing amount placed over a distance of at least a few hundred feet of run and rechecked at frequent intervals, as well as a check of the totals at the end of each

day. Where a leveling course was used, the leveling amount must be taken into account as part of the overall project total, even though it is a separate Item.

Generally, for traffic control, at least two uniformed officers or flaggers will be used at all times. Where the work approaches intersections, towns, and other well trafficked areas, plan well ahead with the Contractor for extra officers as needed.

Truck bodies should not be cleaned beside the road, or a general cleanup operation will be required before job acceptance.

## **SECTION 417 – COLD PLANING BITUMINOUS SURFACES**

### **417.1 - GENERAL**

Cold planing is utilized whenever it is desired to remove part, but not the entire, existing paved surface prior to placing new pavement. The goal may be to restore or maintain curb reveal, repave a bridge deck without increasing the dead load, remove aged oxidized and rutted pavement or provide a smooth riding and durable transition joint between new and older projects.

Originally adapted from coal mining equipment, today's cold planers are designed specifically for the road construction industry and range in size from one foot cutter heads mounted on bobcat loaders, to twelve foot wide ultra large mills. Mainline production work today is often done with a mill weighing fifty tons using a five hundred horsepower engine to drive a seven or eight foot wide mill head. This is the largest size that can be transported between jobs without special permits.

Normal operations have a main milling machine loading directly into dump trucks, that is followed by a trim grinder cutting around curb lines and skewed expansion joints. A bobcat loader and a street sweeper then picks up the millings not loaded by the main conveyer. A water truck, mechanic truck, tool trailer, a compressor and jackhammer are needed to round out the crew's equipment.

Mills are mounted on three or four legs that are adjusted in height to hold the rotor into the work. Each leg has a short crawler track and can be twisted to provide steering and locomotive power. The rotor itself has a series of tooth holders holding carbide teeth in a pattern that brings each successive tooth down and forward through the work beside the groove cut by the preceding tooth. Millings are thrown forward, picked up by a conveyor system, and loaded into the truck under the end of the conveyor. The end conveyor can be moved horizontally and vertically to evenly load the truck then switch to the next truck while all is in motion. Water from an onboard tank is sprayed on the rotor teeth to cool them and provide dust control.



The crew consists of the operator standing on the deck of the machine, the operators of the bobcat and street sweeper, and two ground men checking the actual depths.

At the end of each pass a pile of unloaded millings is left and is loaded by the bobcat or moved onto the next pavement to be ground. Care is taken to remove any material that is in the crawler or end plate paths, as it will affect the depth of cut.

A significant amount of the machine's weight must be applied to hold the rotor down into the work. If the rotor removes all of the existing pavement or a soft spot is encountered there is a tendency for the rotor to dive out of control. This is prevented by a sonic sensor mounted on the main body of the miller, taking readings on a flip out shelf mounted on the side-plate which is allowed to run on the unplanned surface. This shelf allows the sensor to read the side plate elevation instead of the top of curb when planing close to the curb. This same setup allows the grinder to match a previously ground pass smoothly.

Grade sensors similar to those used on pavers can be used to control the depth of cut on each side or a grade sensor on one side plus slope control on the other side can be used. Multiple passes to achieve wider widths match the previous pass on one side and use either slope or depth on the other side as needed. The ends of a pass can be trimmed square with the trimmer planner or the machine operators can dial out to a zero depth and plane a ramp, as the case requires.

#### **417.3 – CONSTRUCTION OPERATIONS**

Before beginning work the limits of the grinding need to be marked out. Areas of variable depths should be clearly marked and plan cross slopes laid out if used. If some or all of the work is not an F- item (final quantity) it should be measured and recorded as soon as possible. It is not uncommon for the paving operation to commence before all the Cold Planing is completed, hence covering much of the area planned.

Existing manhole covers, water gates and catch basin grates should be clearly marked and provisions shall be made to protect catch basins, bridge scuppers and expansion joints from being filled with millings put in place.

When grinding bridge decks the depth of the existing pavement needs to be determined as well as the presence of any paved over expansion joint irons. A review of the original bridge plans at the district maintenance office plus a check of the present curb reveal can provide some guidance. It should be noted that on concrete bridge decks with a steep grade or with skewed ends, concrete may have flowed down to the low end of the deck after the finishing machine had passed and they may be as much as one inch higher than plan.

Millings generally become the property of the contractor and are recycled into pavements as RAP, or used as shoulder gravel. On occasion the contract special provisions will reserve some or all of the millings to the State and will specify whom to contact to properly deliver and stockpile them. Small quantities in remote locations are expensive to haul back to stockpiles. Contractors often wish to give them to the nearest patrol section. A phone call a day or two in advance is needed to determine if this is desired; if not, a local contractor or town crew is usually receptive.

## **SECTION 475 – PORTLAND CEMENT CONCRETE PAVEMENT**

### **475.1 – GENERAL**

This Item will most probably be used when it is necessary to reconstruct a small section of existing concrete pavement.

### **475.2 & .3 – MATERIALS AND CONSTRUCTION OPERATIONS**

When the situation arises that this Item is to be used, the Special Provisions of the contract will provide the information on materials to be used and construction procedures to be followed